In preparing a pressure map it is of course necessary to estimate upper-air temperatures where they are not available from actual observations. This might at first appear difficult. However, surface temperature serves as a starting point for the estimated curve. A careful study of the meteorological factors involved, particularly the history and trajectory of air masses will give a fair picture of temperature conditions aloft. It is especially necessary to check estimates against such actual temperatures as are available when a radiosonde observation falls within the same air mass. With experience, considerable accuracy is possible.

If the pressure map is extended to land areas of any considerable elevation, and the reductions are made from reported sea-level pressure, it becomes necessary in determining T_v to use a fictitious temperature for that portion of the 10,000-foot column which is below the level of the station. This fictitious value is the mean of the current surface temperature and that 12 hours previously. It is that used in reducing station pressure to sea level. On the assumption that reduction to sea level has been made exactly according to this temperature by means of the hypsometric equation, we may without appreciable error construct a temperature curve, which, from sea level to the station level follows the above fictitious temperature, and from the surface level to 10,000 feet, follows the estimated free-air temperatures. The mean of this total curve, with a small correction for water vapor content, gives the value of T_v.

In areas north of Seattle, including the north Pacific, it is usually necessary to apply only slight corrections for moisture content, and as a result, the difference between virtual and actual temperature is small. Using Hann's empirical vapor pressure equation $\left(\log \frac{e}{e_0}=\frac{-Z}{6200}\right)$, the value of average vapor pressure for the 10,000-foot column becomes roughly 0.6 that of the surface vapor pressure. If the dew point is 5° C. (a representative winter value in the north Pacific), the difference between T and T_v is about 0.6° C. (T_v higher than T). In summer the difference may be as much as 1.0° C. or slightly higher. In more southerly latitudes, $T_v - T$ is often considerably greater.

It is recognized that, at times, noticeable error may result in the above pressure determinations where it is difficult to estimate temperatures, but such errors will usually smooth out in drawing isobars on the pressure map. Experience at Seattle in the use of maps so constructed indicates that quite accurate average values of upper winds may be determined from them.

Acknowledgment is due L. P. Harrison of the Weather Bureau Aerological Division for helpful suggestions.

AN UNUSUAL HALO DISPLAY

By D. B. O. SAVILE

[Control Experimental Farm, Department of Agriculture, Ottawa, Ontario, February 1941]

Most of the individual arcs, halos, and parhelia that are associated with an abundance of ice crystals in the atmosphere are not so rare as to merit repeated description, but highly complex displays are far from common. For this reason, and because it seems to throw some light on the precise cause of the sun pillar, the display witnessed at Ottawa, Canada, on January 27, 1941, is worthy of record.

The common 22° halo started to develop before the sun was 3° above the horizon, and was almost continuously distinguishable until sunset. About 10 a. m., E. S. T., the 46° halo became faintly visible to eyes fully adapted to bright light. By 2 p. m. both halos, the horizontal parhelic circle, and the 22° parhelia were all well defined. Developments were then watched from open ground, and notes were taken for some time. During the next hour there were frequent variations in the intensity and extent of some of the components, but those shown in figure 1, and described below, were several times simultaneously visible at approximately 2.30 p. m.

The horizontal parhelic circle, LSM, generally extending about 30° beyond the point of intersection with the 46° halo; occasionally slightly exceeding a semicircle in extent.

The sun pillar, UV, frequently extending about 8° above and below the sun; maximum extent about 10° above and 12° below the sun; scarcely wider at the extremities than at the sun; rare with the sun high in the sky.

Complete 22° halo, ABC; not as bright or as well colored as earlier in the day; the inner edge red-brown.

Upper tangent arc of the 22° halo, DAE; brilliant near point of contact, and better colored than the halo; not distinct to the point where it curves downward.

The 46° halo, GFH; brilliant and strongly colored above the parhelic circle, but faint below and never visible quite to the horizon; both color and brightness generally exceeding those of the small halo during the height of the display.

Circumzenithal arc, JK; taken at first for the contact arc of the large halo—indeed the confusion is often made in print; at solar altitudes between 15° and 25° this arc is practically tangent to the halo and is chiefly distinguished by its brilliant coloring; on this occasion the color sensations predominating were violet, yellow-green, orange, and red; the colors were approximately saturated, and were pure in sharp contrast to the broken colors of the other arcs; generally about 60° of arc distinctly visible, but occasionally slightly more.

The parhelia or mock-suns, P and Q, of the small halo were sometimes extremely brilliant, but the presence of the horizontal circle made their colors indistinct. The extremely rare mock-suns, N and R, of the large halo were distinctly visible several times; they were never brilliant and the horizontal circle rendered both color and extent indefinite; lacking accurate means of measurement, it can only be said that they were in approximately the calculated position several degrees outside the halo. Pernter [1] estimates about seven authentic records of this phenomenon, some early descriptions evidently referring merely to the enhancement of light at the intersection of halo and horizontal circle. The counter-sun, T, was visible for a short time as a diffuse light patch, too inconspicuous to be seen by anyone not looking for it.

[1] Pernter, J. M., *Meteorologische Optik*, Dritter Abschnitt. 1902.

Pernter gives the observers' descriptions and sketches of the three great classical halo displays: The Rome display of 1630, the Danzig display of 1661, and the St. Petersburg display of 1794. The last named, in particular, included a somewhat more prolific display of arcs (some of them inaccurately recorded), but only the Rome display included, doubtfully, parhelia of the 46° halo. None of these displays included a sun pillar. Several other relatively complete displays, accounts of which I have seen, have included certain arcs or mock-suns other than those here described. (See, e. g., MONTHLY WEATHER REVIEW, 48: 330–331, 1920.) The Ottawa display appears, however, to have been one of the few with a definite sun pillar. The distinction is explained by the fact that the pillar is seldom seen when the sun is more than a few degrees above the horizon, whereas most of the other phenomena are best seen when the sun is high. The pillar, which, with the horizontal circle, formed a cross through the sun, was a striking feature of the Ottawa display.

Curiously enough, the sun pillar, although it may be seen dozens of times a year at sunrise or sunset, has never been satisfactorily explained. Minnaert [2] sums up such explanations as have been put forward, and challenges the reader to complete the solution.

It is clear that a pillar formed with a solar altitude of about 25° cannot possibly be explained by the supposition of reflection from ice plates oscillating only slightly from a predominantly horizontal position. My own observations suggest that a distinct pillar is usually observed, other conditions permitting, when there is a steady wind, evident either from its local effect or from cloud forms, blowing approximately at right angles to the line connecting the sun and the observer. Such a wind might cause a preponderance of long hexagonal ice prisms to lie with their axes of symmetry horizontal and in the direction of the wind. This effect could produce a distinct pillar with high solar altitudes. It may well have been the explanation in the case under discussion, for the presence of the parhelia of the large halo proves that there was at times a preponderance of crystals with their 90° refracting edges vertical. Moreover, the wind at ground level was blowing steadily from the southeast; and, since the barometer was falling steadily, the same direction probably prevailed at high altitudes.

A complication arises from the brilliance of the large halo. The fact that it was considerably brighter than the small ring during the height of the display indicates an abundance of platelike crystals to account for refraction through the 90° faces outweighing that through the 60° faces of the randomly arranged crystals. It is doubtful whether such forms could have been predominantly oriented in the position required to give rise to either mock-suns or pillar. Possibly the explanation lies in the umbrella-shaped crystals that give rise to the mock-suns of the small halo. Such forms might lie with their principal axes horizontal in a strong wind and yet refract predominantly through their 90° faces. An alternative explanation is suggested by the occasional observation of a vague lattice structure in the cirro-nebula, which suggests that there were actually two distinct layers of cloud involved. Possibly there were different crystals forms and even different directions of movement in the two sheets.

It was hoped that some upper-air observations might be obtainable for the time of this display; but the clouds were far above the levels commonly utilized in commercial aviation, and no pertinent information was available. I have, however, to thank Mr. Jefferson, of Trans-Canada Air Lines, for his offer to make balloon observations, should future displays warrant the attempt.

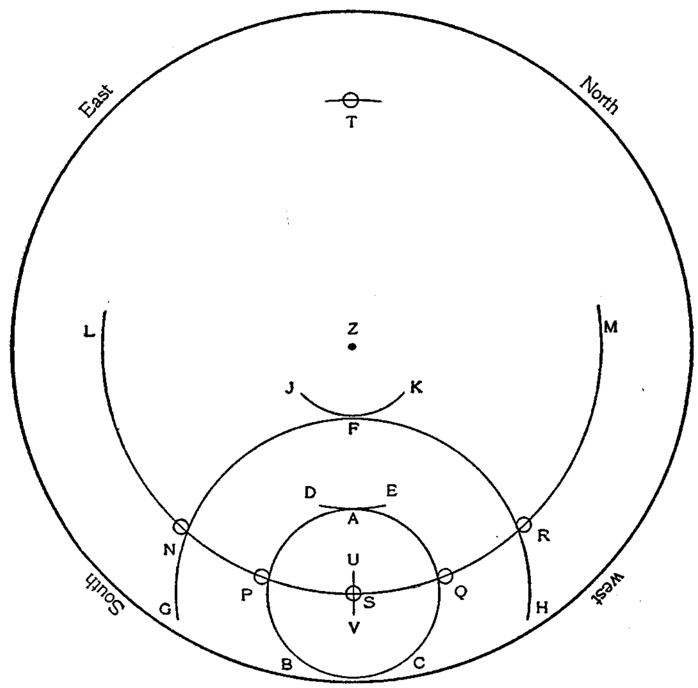

FIGURE 1.

[2] Minnaert, M. *Light and Colour in the Open Air.* London, 1940. *Cf.* MONTHLY WEATHER REVIEW, 63: 57–58, 1935.

AEROLOGICAL NORMAL DATA

Monthly tables, showing normal values of temperature and relative humidity for standard levels up to 5 kilometers, were recently printed by the Weather Bureau. These tables include all available kite, airplane, and radiosonde records for the United States as well as for St. Thomas, V. I., Coco Solo, C. Z., and Pearl Harbor, T. H., through June 1939.

A limited supply of these tables are available for distribution and may be secured by applying to the Chief, United States Weather Bureau, Washington, D. C.